Scientific Curriculum Vitae
Beate Heinemann

Positions held:

1996	Universitaet Hamburg/Germany: Diploma in Physics with Astronomy as second subject: grade "sehr gut" (=very good)
1996-1999	PhD at DESY: grade "ausgezeichnet" (=excellent), prize of University of Hamburg for best thesis in 1999
1999-2002	PPARC Postdoctoral Fellowship held at University of Liverpool
2002-10/2004	PPARC Advanced Fellowship held at University of Liverpool
10/2004-	Royal Society Fellowship held at University of Liverpool

1996-2000: H1 Experiment at DESY, Hamburg/Germany

- **Physics Measurements**:
  I focused on measuring cross sections of Deep Inelastic Scattering via both Neutral and Charged Current processes at the highest momentum transfers at HERA. These measurements at high energy constitute an important test of the Standard Model and could reveal New Physics by e.g. resonance production or t-channel exchange of a new particle.
  In detail, I performed:

  - Search for a lepton-quark resonant production e.g. a leptoquark or a squark using the 1994-96 data: this measurement caused a lot of excitement within the HEP community in early 1997. I had at that time just started my PhD thesis and had just been appointed as Monte Carlo coordinator of H1. Despite not performing the central analysis, I contributed significantly by producing all the background Monte Carlo samples and crosschecking the analysis for the publication.

  - Measurement of the Neutral and Charged Current cross sections at high Q^2. Being inspired by the interesting results in the resonance searches above I wanted to understand the data at high precision in order to determine whether the observed excess was due to a statistical fluctuation or whether it was due to systematic effects that may be present in the data. I incorporated the data taken in 1997 and did a full recalibration of the electron. The result was that the previously observed excess was a statistical fluctuation and became less significant with the inclusion of more data. The data agreed well with the Standard Model at all values of Q^2 and x. I thus interpreted those data in terms of a measurement of the proton structure function F_2 and improved the precision by more than a factor of 5 compared to previously published results. This measurement of both the Neutral and Charged Current Cross Sections at HERA was

published and is also my thesis subject. I also, for the first time, measured the Charged Current cross section double-differentially in x and $\mathbf{Q^2}$ and found it to be well described by existing parametrisations of the parton distribution functions and NLO QCD.

- I then repeated that measurement using the data taken in 1999 and 2000 and extended it to lower energies using a trigger I had developed. This extension to lower energies made the first extraction of the longitudinal proton structure function F_L at high Q^2 possible. The measurement of the longitudinal structure function is particularly sensitive to higher order QCD corrections. In conjunction with the electron-proton data I was also able to extract the structure function xF_3. These measurements are still the highest precision measurement in this kinematic range to date and are used in all the global NLO and NNLO QCD fits.

- **Positions of Responsibility**:

  - Monte Carlo coordinator of the entire experiment: this position was of central importance for many publications in H1 and I was in charge of ensuring the fast production of the samples requested by the physics groups.
  - Shift leader being responsible for efficient data taking for 1 week per year and leading a shift crew of 4 people
  - Run coordinator being responsible for the H1 detector operation and the interactions with the HERA accelerator and the other experiments for a 2-week period each year
  - Data Quality representative of the Electroweak Group being in charge of checking the triggers and the latest data and giving reports on a bi-weekly basis.

- **Technical achievements**:

  - Design of bookkeeping system for Monte Carlo data sets based on an oracle database and interfaced to the www with cgi-scripts.
  - Implementation of a new charged current trigger, which allowed an extension of the phase space to high inelasticitiy y.
  - Implementation of a new low energy electron trigger in the Liquid Argon calorimeter which allowed the first measurement of the longitudinal structure function of the roton at high Q^2.
  - High precision electron energy calibration (0.3-3% depending on the angle of the electron) using Neutral Current and QED Compton events. I implemented my calibration into the standard H1 software and is still used to date for all analyses of H1 data taken up to 2000.
  - Calibration of the hadronic energy scale to 1-2%
  - Alignment of the Liquid Argon Calorimeter with respect to the drift chamber system.

- Calibration of the wire drift chamber CJC using a program “MILLIPEDE” taking into account all correlations cell by cell.

2001-2004: CDF experiment at FNAL, Chicago, USA:

- **Physics Measurements**:

I have a strong interest in finding physics beyond the Standard Model in direct searches. Thus I decided to switch from HERA to the Tevatron, which, in my opinion, has a greater potential for discovering new physics. However, I initially focused on performing classic measurements, which hav**e** an indirect sensitivity to new physics. I considered it important to first make basic measurements in an environment where the CDF detector was basically brand-new and its performance not fully understood**.** I have mostly focused on experimentally clear signatures such as photons, leptons and imbalance in transverse momentum. I have and am performing all those measurements together with students and post-docs from both Liverpool and other universities:

- Measurement of the cross sections and kinematic distributions of $W\gamma$ and $Z\gamma$ production at Run 2. This measurement is currently being prepared for publication and is also used to extract the trilinear gauge couplings of the electroweak gauge bosons. Both the $W\gamma$ and $Z\gamma$ measurements are the highest precision measurements to date. I have guided one Japanese, US and one UK student who made this measurement.

- I am now working on extending this measurement by demanding an additional photon in the event which reduces any Standard Model contribution by more than a factor of 100: $W\gamma\gamma$ and $Z\gamma\gamma$ production and the extraction of quartic couplings from those.

- Together with a post-doc and a student from Liverpool, I am working on the search for Supersymmetry in chargino-neutralino production. This is one of the most promising channels to search for new physics at CDF and requires a detailed understanding of low momentum leptons in terms of trigger and identification efficiency as well as background due to jets (particularly from semileptonic b-decays). We are making good progress on this analysis and are confident to exceed the LEP limits on neutralino and chargino masses by Spring 2005.

- I recently started supervising a new student from Liverpool University on searches for new physics in diphoton events. This is a particularly important measurement in view of the LHC discovery potential of a light Higgs boson. We have so far interpreted the high mass data in terms of a limit on Graviton production in the Randall-Sundrum model . Now, we are working on interpreting the data in terms of the Higgs boson decaying to

two photons and on extending the phase space to larger angles and thus the sensitivity to new physics.

- I am also involved in measurements of exclusive production of diphotons (with a graduate student from Canada) aiming at testing the theoretical predictions for exclusive Higgs boson production at the LHC and to gain a deeper understanding of non-perturbative QCD. I have also published a phenomenological analysis on this subject together with Brian Cox and Jeff Forshaw from Manchester University. Our work has significantly impacted on this subject and both the ATLAS and CMS experiments are now evaluating the possibility of installing forward detectors at the LHC. In particular for a low mass Higgs boson, this may improve the discovery potential of the LHC. However, the cross section calculations are rather uncertain and it is vital to test them at the Tevatron in order to be able to evaluate the Higgs discovery potential in this channel at the LHC. Thus I am now focusing on exclusive diphoton production, which has a very clean experimental signature and a hard scale for perturbative calculations (compared to the alternative di-jet and the chic production channels, respectively).

- Very recently, I started to supervise an undergraduate student from Chicago University on a stop quark search with a final state of 2 photons, 2 jets and large imbalance in transverse momentum. This measurement has never been done before. In GMSB SUSY models there is a clear discovery potential, particularly in non-minimal models.

- I have kept a strong interest and involvement in measurements of the mass of the top quark throughout my time at CDF. It is anticipated that the precision on this measurement will be limited by the understanding of the absolute energy scale of jets and I thus focused on this subject. Under my leadership, the systematic error on the jet energy scale improved by about 50%. Even though I retired from this leadership due to time constraints 1 one month ago, I continue to guide the people working on this subject. I anticipate a further reduction by 50% on a time scale of a few months due to the improvements in the detector simulation I initiated together with Young-Kee Kim and Anwar Bhatti. I also worked on trying to improve the jet energy resolution by combining tracing and calorimeter information, which will become crucial for the Higgs boson search at the Tevatron with higher luminosity.

- **Positions of Responsibility**:

  - Co-head of calorimeter reconstruction (2001-2003);

- Co-Convener of the "Photon Group" which is concerned with analyses involving photons, particularly the selection efficiencies and background estimates (2002-2003);

- Co-Convener of "Jet Corrections Group" which is concerned with the understanding of jets and particularly the systematic error on the jet energy scale which is e.g. vital for the measurement of the mass of the top quark (2003-2004);

- Co-Convener of the "Diboson Group": this is a sub-group of the "Electroweak Physics Group" guiding the measurements of WW, WZ, ZZ, $W\gamma$ and $Z\gamma$ production and the extraction of the trilinear gauge couplings (2003-2004);

- Co-Convener of the "Exotics Physics Group": this group overlooks currently about 60 analyses searching for New Physics beyond the Standard Model. I am responsible for ensuring high quality of these analyses, overviewing five subgroups (e.g. SUSY, Higgs, etc.) and appointing comveners for those, covering all possible new physics scenarios as person-power allows, releasing the results to be shown at international conferences and ensuring their publication in reviewed journals (2004-2006);

- Leader of the CDF Liverpool group including currently 4 students, 4 post-docs and 2 senior lecturers (2003-?). This includes ensuring that our responsibilities within the experiment are covered (currently monitoring and alignment of the Silicon detectors), the interaction with the funding agencies and the CDF management.

- **Technical achievements**:

  - Commissioning of the calorimeter energy measurements and trigger.

  - Commissioning of photon identification, backgrounds and triggers.

  - Implementation of a mechanism to calibrate the calorimeter energies offline to the best knowledge available using the CDF databases: this became particularly important when it was noticed that the forward calorimeter signal significantly degrades with time at a rate of about 3-10% per year depending on the angle, due to aging of the photomultipliers.

  - Foundation of a task force which significantly improved the simulation of the calorimeter response to charged hadrons, particularly in the forward calorimeters. This improvement in the simulation will lead to a reduction

of the systematic error on the top quark mass by about a factor of two in the very near future.

- Studies of jets: photon-jet balancing, correction to jets for multiple interactions and low-energy linearity of the calorimeter.

- Implementation of a z-vertex algorithm that determines the z-vertex of the primary interaction and the number of interactions per event.

- Shift leader, leading a crew of 4 people and having responsibility for efficient data taking and safety for 3 1-week periods per year.